Confirmation of an established population of exotic turtles in urban Sydney.

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ABSTRACT

I investigated whether exotic turtle species were capable of establishing breeding populations in the Sydney area and confirmed that two exotic species were present: *Trachemys scripta elegans* and *Clemmys marmorata*. Mature females of both species were recorded with shelled eggs in the oviducts and evidence of nesting by *T. s. elegans* species was noted. *Trachemys scripta elegans* were observed in a range of sizes which suggested that it has established a foothold, at least in southern Sydney. Competition from this exotic species could have a detrimental impact on the local species, *Chelodina longicollis* and *Emydura macquarii dharuk*.

Key words: *Trachemys scripta elegans, Emydura macquarii dharuk, Chelodina longicollis,* freshwater turtles, invasive species, pest turtles.

Introduction

Freshwater turtles (*cf*. tortoises, terrapins) are popular pets (Alderton 1986; Connor 1992; Covington 1995; Roberts 1988). In Australia, such animals may originate from wild populations (Griffiths 1997). For example, *Elusor macrurus* was known to science from Victorian pet shops for over 20 years before it was 'discovered' in the Mary River in 1990 and described by Cann and Legler in 1994. Others, such as the ubiquitous pet turtle, *Trachemys scripta elegans* (Alderton 1986), are exotic.

Endemic to eastern United States of America and northern Mexico, *T. s. elegans* Red-eared sliders are raised on 'turtle farms' in Louisiana and exported around the world (Hughes, 2000). Within their range they have declined due to pressure from unsustainable farming (Warwick 1986) while, coincidently, the number of exotic populations of 'escaped' pets have expanded (Connor 1992; Hutchinson 1992). Limited data are available on the status, distribution and ecological impact of these feral populations (McCoid 1993; Ng *et al*. 1993) but they have been reported from a wide range of habitats around the world (eg. Italy, Luiselli *et al*. 1997; South Africa, Israel, Branch 1998; Taiwan, Chen and Lue 1998; Thailand, Cambodia, Malaysia and Australia CITES 2003; Guam, McCoid 1993; Singapore, Ng *et al*. 1993; Sweden, Nilson and Andren 1986; Japan, (http://homepage3.nifty.com/japrep/englishtop.htm; New Zealand, Australia, Stimson and Wells 1995). Indeed, in a review of a book of the turtles of Borneo and Peninsular Malaysia by Liat and Das, Levell (2000) indicated that the introduced *T. s. elegans* was 'almost universally' present in Borneo and Peninsular Malaysia. As a result of these widespread feral populations, *T. s. elegans* have been listed among the top 100 'worst invasive species' on the Invasive Species Database (ISSG, 2005).

Historically only the endemic *Chelodina longicollis* was included in published species lists for the Sydney region (eg. Ehmann 1992; Cogger 1996). More recently Cann (1998) has described an endemic sub-species of *Emydura macquarii, E. m. dharuk*, from the Sydney basin. There have also been several exotic species reported in the region (Stimpson and Wells 1995; Griffiths 1997). *Trachemys scripta elegans* and *Emydura signata* have been found in the Royal Botanic Gardens, Hacking River and Royal National Park. Other herpetologists have reported *T. s. elegans* from the Sydney Basin including the Lane Cover and Upper Shoalhaven rivers, Centennial Park (Sydney) and Gosford (Central coast New South Wales; Stimpson and Wells 1995). Individuals have also been reported in the Hawkesbury - Nepean and adjacent wetlands (Benson 1996). In year-long studies undertaken by members of my research group and focused on *C. longicollis,* incidental catches included one mature *T. s. elegans* in the Upper Parramatta River catchment (Ross 2000) and two *Elseya latisternum* from the Lane Cove River (Rosser 1997).

More recently, a breeding population of *T. s. elegans* has been identified in the Pine Rivers area of Southern Queensland (NRM 2004) and there have been sightings in other areas north of Brisbane, including a single individual from Bundaberg (Van de Wetering 2005) and the Gold Coast area (NRM 2004). A single individual has also been found in a backyard in Canberra (Rheinberger 2003).

In Australian aquatic environments, the cane toad, *Bufo marinus*, European carp, *Cyprinus carpio* and mosquito fish, *Gambusia* spp. are widely recognised to have had devastating impacts upon native wildlife. Overseas *T. s. elegans* has also had a major impact (eg.

Levell 2000) and could present a similar hazard in Australia. Consequently surveys were undertaken for *T. s. elegans* in areas of Sydney's waterways where they were previously reported to occur to determine their presence and reproductive potential.

Methods

Initially, capture techniques were trialled in a pond at Taronga Zoological Gardens (Sydney) that contained *T. s. elegans*. Standard yabby traps (for illustration see http://www.dpi.nsw.gov.au/__data/assets/pdf_file/54204/Fishing_for_yabbies_in_New_South_Wales_150.pdf) and fyke nets (for illustration see design http://www.fipec.qc.ca/ahtml/averveux.html) were used. Half of the traps/nets were baited (sardines) and the others were left unbaited. These were set during the day (0800 – 1700 hours) and all treatments yielded *T. s. elegans*.

In the 1996 breeding season for *C. longicollis* in the area (October – November; Dalem 1998), a survey was undertaken of the seven sites within the Sydney environs (Table 1) where Stimson and Wells (1995; Stimson pers. com.) considered that there had been reliable sightings of *T. s. elegans*. I sampled each of these sites over a single randomly allocated two-day interval. However, at Yeramba Lagoon, where *T. s. elegans* were trapped, sampling was extended to a total of 12 days between October 1996 and March 1997. Sampling over this period was undertaken for two days per fortnight. Two further sites were surveyed (Cabramatta and Eastern creeks) in March 1997, immediately after response to media coverage of the project resulted in additional reports of sightings.

A total of 22 traps (20 yabby traps and 2 fyke nets) were set at each site. This enabled substantial coverage of the land/water interface of waterbodies and, on occasions, the entire perimeter. Traps/nets were positioned in shallow waters (1.5 m) at the margin of waterbodies. From a randomly chosen starting point, they were placed systematically at 100 m intervals. In the initial survey fyke nets were set on Friday afternoon, cleared Saturday and Sunday morning, and then again cleared (and removed) at dusk. Yabby traps were set and cleared at regular intervals during daylight hours over the same period.

Sampling in Yeramba Lagoon occurred between October 1997 and February 1998. Traps were randomly set within accessible areas. On this occasion, 12 fyke nets (two at each location) were set on one weekend/month. They were also positioned on Friday afternoon, cleared Saturday and Sunday morning and removed at dusk. In addition to trapping, on each visit a thorough search was made for signs of nesting activity and basking turtles.

The wetland area declined as the season progressed and sampling was abandoned when low water level precluded effective trap/net setting.

All captured turtles were sexed and palpated for oviductal eggs. Radiography was used on the exotic species and a sub-sample of gravid *C. longicollis* to verify the presence of shelled eggs in the oviducts. Endemic turtles were released at point of capture, while exotics were euthanised under veterinary supervision and dissected to determine the number of ovarian follicles/eggs and to confirm the results of the radiography.

Results

Chelodina longicollis was encountered in all nine survey sites and *E. m. dharuk* was observed at all sites except Bicentennial Park. Two exotic species (*T. s. elegans* and *Clemmys marmorata*) were collected at Yeramba Lagoon (Table 1) where *C. longicollis*, *E. m. dharuk* and *T. s. elegans* were trapped together in the same trap/net on one occasion.

Only female *T. s. elegans* and *C. mormorata* were captured and the sex ratio of *C. longicollis* was significantly different from a 1 : 1 sex ratio (${}^{2}_{1,0.05}$ = 9.09). More females than males were captured.

Dissection of *T. s. elegans* and *C. marmorata* revealed that the *C. marmorata* and five of the six *T. s. elegans* had developing ovarian follicles. The exception was an immature female, the smallest of the *T. s. elegans* captured. Representatives of all species trapped (*T. s. elegans, C. longicollis, .E. m. dharuk, C. marmorata*) were represented by females of breeding size classes. Radiography confirmed that representatives of three species (*C. longicollis*, *E. m. dharuk* and *T. s. elegans*) had shelled eggs in their oviducts.

Table 1. Numbers of turtles trapped in October and November 1996 at sites in urban Sydney where Red-eared sliders *Trachemys scripta elegans* had been previously reported due to incidental sightings (Yeramba Lagoon numbers represent the mean numbers collected in six two-day netting sessions compared to one two-day netting session in each of the other sites).

Sydney location	*C. longicollis*	*E.m.dharuk*	*T.s.elegans*	*C. marmorata*
Bicentennial Park	5	0	0	0
Centennial Park	23	126	0	0
Manly Dam Reserve	3	2	0	0
Middle Harbour	4	1	0	0
Mirrambeena Lakes	5	1	0	0
Nurrangingy Reserve	5	1	0	0
Cabramatta Creek	2	3	0	0
Eastern Creek	3	1	0	0
Yeramba Lagoon	8.2	0.2	1	0.2

Table 2. Clutch characteristics of a sample of turtles netted from Yeramba Lagoon between October and November 1996 that were palpated and subsequently radiographed to confirm that they had shelled eggs in the oviducts

Species	Carapace length (mm)	Number/clutch	Mean egg width/clutch (mm)	Egg width rang/clutch (mm)
C. longicollis	210.2	14	19.5	18.52-20.09
	196.5	7	18.25	17.30-19.07
	188.0	10	18.46	17.74-18.80
	198.0	10	19.01	18.74-19.58
	199.0	6	17.71	17.33-17.79
	209.7	14	19.41	19.16-20.25
	179.5	14	19.41	19.16-20.35
	184.9	6	17.21	17.21
	183.4	6	19.5	19.5
E. m. dharuk	192.5	14	17.74	17.39-18.38
T. s. elegans	176.9	7	23.93	22.91-24.86
	204.8	10	24.47	23.89-24.86
	206.2	10	22.82	22.33-23.30

Dissection showed that the smallest *T. s. elegans* caught (108.2 mm) had follicles of <5mm, whereas the other exotic turtles captured had follicles within the size classes of <5 to <15mm. Three *T. s. elegans* had follicles >15mm and three had clutches of shelled eggs of between 7 and 10 that were identified through radiography and confirmed upon dissection (Table 2).

Adult *T. s. elegans* grew to a larger size and weighed more at a specific length than did the native species or *C. marmorata* (Figure 1).

Three disturbed nests, marked by fox scats, were found adjacent to a walking track and approximately 200 m upslope of the Lagoon. All nests contained the remains of eggs. Based on comparison with eggs of the two species, in terms of the size and comparative thickness of the shell, I assumed that two nests contained the remains of *C. longicollis* eggs and the third had the remains of *T. s. elegans* eggs. The eggs had the characteristic 'slit' of eggs taken by foxes (*cf.* Chessman 1978). I also inspected a photograph taken by a local resident (Mr Darryl McKay) clearly showing a female *T. s. elegans* digging a nest in the vicinity of Yeramba Lagoon.

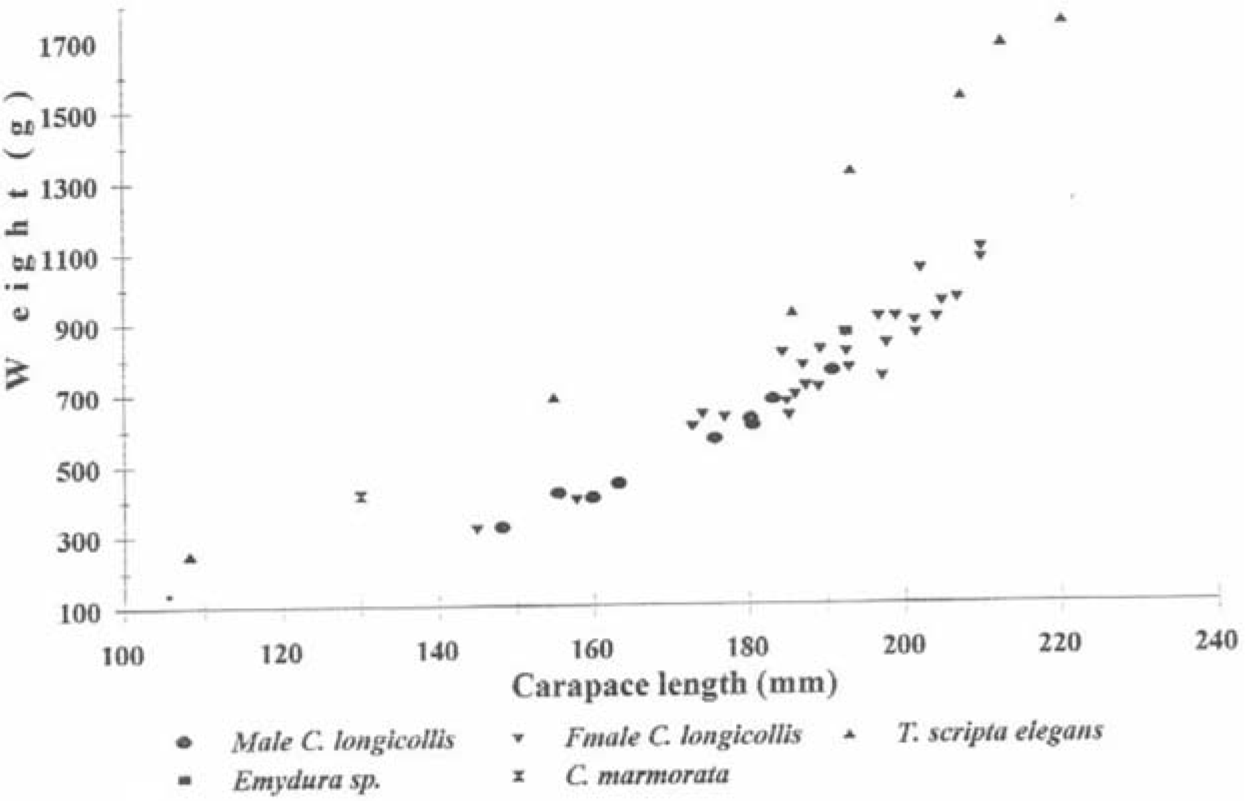

Figure 1. Comparison of carapace length body and weight of turtles trapped in Yeramba Lagoon (south Sydney) between October 1996 and March 1997.

Discussion

These captures confirm that exotic turtles, *T. s. elegans* and *C. marmorata* were established and breeding in Yeramba Lagoon (Southern Sydney). All captured exotics were females. Although *T. s. elegans* have temperature-dependent sex determination (Takada and Koopman 2003), this does not necessarily indicate a deficit of males in the population. The sample of *C. longicollis* was also biased towards females in that year. Seasonal difference in catchability occurs in *C. longicollis* and males are often under-represented in spring/summer catches. There are also inter-year differences in capture probability by sex (Dalem 1998). Capture probabilities due to differential habitat preferences may also vary among species and was demonstrated to differ between years for *T. s. elegans*, since despite substantially increased sampling effort in the second year and sampling elsewhere since that time, few exotics have been captured.

In the unlikely event that only female *T. s. elegans* were present, this does not preclude establishment of an exotic population. Females may produce fertile offspring for up to five years after insemination. They are also capable of multiple clutching (2/3 clutches/season; Covington 1995). The number of large follicles observed, if correlated with the number of eggs delivered, suggests that *T. s. elegans* multi-clutch in the Sydney region (Table 3). Clearly, this species has the potential to produce large numbers of hatchlings annually in the Sydney region.

Three species (*C. longicollis*, *T.s. elegans* and *E. m. dharuk*), collected from the same trap/net, had shelled eggs in the oviducts. This is confirmation that their reproductive activity, at least for part of the breeding cycle, is synchronised. Disturbed nests provided evidence that nesting also occurs in the same habitat.

Within the range of *T. s. elegans* they have been reported to lay a maximum 12 eggs per clutch (Roberts 1988). However, in South Africa they typically produce 15 eggs and a maximum of 23 per clutch (Alderton 1986; Branch 1998). The three *T. s. elegans* with shelled eggs had clutch sizes that ranged between seven and ten (Table 2). Once hatched, *T. s. elegans* would not be constrained by Sydney's climate given their tolerance of a wide range of thermal regimes (Churchill and Storey 1992). In captivity, they are active in waters between 24 - 30°C (Roberts 1988). As a consequence there is no impediment to the hatchlings surviving in Sydney's waters.

The exotic *T. s. elegans* had similar carapace size to *C. longicollis* (Figure 1). However, they have the potential to grow larger (280mm, Branch 1998) than *C. longicollis* (250 mm, Cogger 2000), are heavier, more aggressive, and omnivorous (Roberts 1988). Unlike *C. longicollis* and *E. m. dharuk*, at least in an aquarium, they will attack and maim aquatic species larger then themselves (Schell pers. comm. UWS).

Trachemys scripta elegans inhabit a wide range of impoundments and rivers, including the saline reach of rivers and salt marshes (Lehrer 1990). They can also rapidly expand their range via over-land movement (Ernst *et al*. 1994). The local abundance of *C. longicollis* fluctuates due to competition for resources in ephemeral ponds, interaction with other turtles and environmental variability. In the absence of predatory fish and other turtle species, they take advantage of dense populations of prey in temporary waters (Georges *et al*. 1986). Based on comparative numbers captured (e.g. Ross 2000), *E. m. dharuk* occurs in lower numbers than *C. longicollis* and, therefore, is potentially vulnerable to increased competition, at least in urban areas. Exotic populations of *T. s. elegans* may impact on native species where they become established if they have a competitive advantage over Australian species. This has occurred in Malaysia and Borneo (Levell 2000) and, although based on limited data, it would appear that they out-complete the aquatic species (fish and native turtles) in South-eastern Queensland (O'Keefe 2005).

The number of *C. longicollis* trapped during the survey was relatively low at virtually all sites, compared with numbers trapped elsewhere. Members of my group have trapped up to 32 individuals/net in 24 hours, while 10-15 individuals are common during times of peak activity. Elsewhere in Australia, their density has been estimated at 236 ha^{-1} (Chessman 1978) and 400 ha^{-1} (Parmenter 1976) in farm dams and 159 ha^{-1} in riverine environments (Chessman 1978). Within the Eastern Creek catchment, a total census of a farm dam revealed a density of 370 ha^{-1} (Burgin *et al*. 1999). This indicates that despite being common and widespread, trapped samples do not always reflect this phenomenon. The capture rate obtained in Yeramba Lagoon, dominated by females in all species collected, indicates that conditions were suboptimal

Table 3. Number of ovarian follicles in the reproductive tract of seven individuals representing two exotic species that were netted at Yeramba Lagoon between October and November 1997.

Species	Carapace length (mm)	Follicle size class (mm)			
		<5	5.1-10	10.1-15	>15
T. s. elegans	193.1	>100	35	15	25
	212.5	>100	51	10	9
	220. 3	>100	26	49	0
	155.0	>100	26	49	0
	185.6	>100	9	13	27
	108.2	>100	0	0	0
C. marmorata	130.0	>100	4	10	0

for male turtle capture and, on this basis alone, it is hypothesised that the results are an underestimate of the numbers present for both exotic and native species.

Rosser (1997) observed that *E. m. dharuk* made up 30% of the year's catch in the Lane Cover River, while *E. latisternum*, translocated from more northerly rivers, represented 3%. By comparison, in 1996, *T. s. elegans* represented 10.5% of the catch from Yeramba Lagoon and *C. marmorata* 2%. If it were assumed that catchability was equivalent for both *C. longicollis* and *T. s. elegans*, based upon previous estimates of population size (159 – 400 ha^{-1}), some 17 – 42 *T. s. elegans* may have been present in the lagoon. The only census count available (370 ha^{-1}) places the potential numbers of exotic *T. s. elegans* at close to 40 ha^{-1}. The lack of males among the catch suggests that the numbers were much higher than indicated by the sampling and the subsequent estimates.

Evidence of breeding, nesting and the observations that animals were present in a range of sizes with none of the characteristics of 'escaped' pets (eg. scuffing from the carapace or shortened claws due to scraping on cement edges), confirm that *T. s. elegans* have obtained a foothold in south Sydney. It may be more widely established as indicated by the widespread incidental reports of the species.

Acknowledgements

The fieldwork for this project was largely undertaken by the Steve Emerton and funded by the University of Western Sydney.

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APPENDIX I

Red-eared Slider.

Photo: University of Western Sydney, media unit.